D0 Upgrade Electronics

New FE
L1 Trigger CFT Design
Version 1

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Revised CFT L1 track finder algorithm

A revised CFT track finder algorithm has been developed. The former algorithm, which is part of the base line design, reported out a list of six tracks. For each of these tracks an index is given which represents which angular, phi, and momentum, Pt, bin the track belonged to. The size or resolution of this bin in delta phi and delta Pt was satisfactory for the needs of the muon L1 trigger and for a stand alone CFT L1 (or L2) trigger. But for the SVTpp and for matching with other sub-detectors in the L2 global this resolution was not precise enough.

The base line design algorithm found tracks in two dimensional, 2d, bins of 16 bins in phi by 4 bins in Pt. A Pt and phi index was assigned each of these 64 bins and the 6 highest Pt tracks from this list of from zero to 64 tracks was loaded into a six deep track FIFO for transmission to the rest of the trigger system. To assign an index to each of these 64 possible tracks the list of 64 was divided into 8 groups of 8. The 8 bits of each group was used as an address to enter a ROM. Each memory address of this ROM contained the appropriate bits for a six deep FIFO of track indexes corresponding to the tracks found for the bit pattern of the address. This method is very fast but each ROM requires a great deal of resources. Expanding the 2d track bins beyond 64 is impossible and a different methodology was sought.

The advantage of the ROM solution is that it in effect does a sort for six items over 64 bins in parallel. 64 bins can be scanned within a couple of clock cycles instead of six times 64 clock cycles. An alternative to this sort is to expand the number of bins so that the probability of more than one track in each bin is small. Then the bins are arranged within the code in the order in which the final track list is to be sorted. Therefore no sorting is necessary. That is what the revised algorithm attempts to do.

	Pt Index										
Phi Index	1	2	3	4	5	6	7	8	9	23	24
1	101	201	301	401	501	601	701	801	901	2301	2401
2	102	202	302	402	502	602	702	802	902	2302	2402
3	103	203	303	403	503	603	703	803	903	2303	2403
4	104	204	304	404	504	604	704	804	904	2304	2404
5	105	205	305	405	505	605	705	805	905	2305	2405
6	106	206	306	406	506	606	706	806	906	2306	2406
7	107	207	307	407	507	607	707	807	907	2307	2407
8	108	208	308	408	508	608	708	808	908	2308	2408
9	109	209	309	409	509	609	709	809	909	2309	2409
10	110	210	310	410	510	610	710	810	910	2310	2410
11	111	211	311	411	511	611	711	811	911	2311	2411
12	112	212	312	412	512	612	712	812	912	2312	2412
13	113	213	313	413	513	613	713	813	913	2313	2413
14	114	214	314	414	514	614	714	814	914	2314	2414
15	115	215	315	415	515	615	715	815	915	2315	2415
16	116	216	316	416	516	616	716	816	916	2316	2416
17	117	217	317	417	517	617	717	817	917	2317	2417
47	147	247	347	447	547	647	747	847	947	2347	2447
48	148	248	348	448	548	648	748	848	948	2348	2448

Table 1

The equations are sorted by Pt value into 24 bins and by Phi index into 48 bins giving 1152 2d bins. Each 2d bin is assigned an index number that codes its phi bin value and its Pt bin value. Table 1 above shows the bins and an example of how the index is assigned. (In this example the phi and Pt indexes are coded as two digit decimal numbers. In the PLD they are coded as bits.) The sorting criterion is arbitrary. The equations could be sorted for example according to the mean Pt of the equations and the mean phi value at a particular radius. They could be sorted by outer fiber bin and inner fiber bin. They could be sorted by outer fiber bin and offset number. All that is required is that 2d bins of 48 phi units by 24 Pt units are formed.

If any equation in a 2d bin is true, that is a track is found for any equation in that group, the 2d bin is set as true. Next the bins are scanned in groups of 6 over the Pt index, low index to high index. One scan group of the total 192 is shaded in gray in table 1. The scan is made from low Pt index to high until a 2d bin which is true is found. When a true is found the scan is stopped and the index of that first 2d bin is recorded. Any other tracks which may be in this group are lost.

Phi Index	1	2	3	4
1	iijj	iijj	iijj	iijj
2	iijj	iijj	iijj	iijj
3	iijj	iijj	iijj	iijj
4	iijj	iijj	iijj	iijj
5	iijj	iijj	iijj	iijj
6	iijj	iijj	iijj	iijj
7	iijj	iijj	iijj	iijj
8	iijj	iijj	iijj	iijj
9	iijj	iijj	iijj	iijj
10	iijj	iijj	iijj	iijj
11	iijj	iijj	iijj	iijj
12	iijj	iijj	iijj	iijj
13	iijj	iijj	iijj	iijj
14	iijj	iijj	iijj	iijj
15	iijj	iijj	iijj	iijj
16	iijj	iijj	iijj	iijj
17	iijj	iijj	iijj	iijj
47	iijj	iijj	iijj	iijj
48	iijj	iijj	iijj	iijj

Table 2.

Table 2 above shows the result of this first step. The 2d bin index for each of the groups of 6 2d bins is recorded as index iijj. If there was one or more found track in any of the table entries above the value of iijj is the 2d bin tag for the lowest Pt index track. If there was no track the value of iijj is zero.

Next groups of 6 indexes are zero suppressed and loaded into FIFO's. Examples of these groups are shown as shaded in table 2 above. After this step there are 32 FIFO's each with from zero to six track indexes.

	Pt Index			
Phi Index	1	2	3	4
1	fifo	fifo	fifo	fifo
2	fifo	fifo	fifo	fifo
3	fifo	fifo	fifo	fifo
4	fifo	fifo	fifo	fifo
5	fifo	fifo	fifo	fifo
6	fifo	fifo	fifo	fifo
7	fifo	fifo	fifo	fifo
8	fifo	fifo	fifo	fifo

Table 3

Table 3 above shows these 32 FIFO's. Remember that each of these FIFO's is from zero to six tracks long. Next the FIFO's are merged in pairs. The shaded areas in the above table illustrate this. All the tracks from the first FIFO are loaded into a new FIFO. Any open slots in the new FIFO are then loaded with tracks from the second FIFO. This process is from low index to high index value. At the end of this step there are 16 FIFO's.

	Pt Index			
Phi Index	1	2	3	4
1	fifo	fifo	fifo	fifo
2	fifo	fifo	fifo	fifo
3	fifo	fifo	fifo	fifo
4	fifo	fifo	fifo	fifo

Table 4 shows these 16 FIFO's. The same process is repeated again for these 16 FIFO's as shown by the example shaded area in table 4. At the end of this step there are 8 FIFO's.

	Pt Index			
Phi Index	1	2	3	4
1	fifo	fifo	fifo	fifo
2	fifo	fifo	fifo	fifo

Table 5 above shows these 8 FIFO's, which are in turn load in pairs.

	Pt Index			
Phi Index	1	2	3	4
1	fifo	fifo	fifo	fifo

Table 6 shows the result of this combining. At this stage the FIFO's are completely collapsed in phi and we have four FIFO's each of which is for a separate Pt range. These four FIFO's are combined in pairs down to two.

	Pt Index	
Phi Index	1	2
1	fifo	fifo

Table 7 shows these two FIFO's. They are in turn combined into a single FIFO.

	Pt Index
Phi Index	1
1	fifo

Table 8 shows the final, single 6 track deep FIFO. And the process is finished.

Realization of the Algorithm in PLD

A realization of the algorithm from the 24 by 48 array of binary bits to the final single 6 deep track FIFO has been done. Xxxxxx……

	Pt Index										
Phi Index	1	2	3	4	5	6	7	8	9	23	24
1	101	201	301	401	501	601	701	801	901	2301	2401
2	102	202	302	402	502	602	702	802	902	2302	2402
3	103	203	303	403	503	603	703	803	903	2303	2403
4	104	204	304	404	504	604	704	804	904	2304	2404
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14	114	214	314	414	514	614	714	814	914	2314	2414
15	115	215	315	415	515	615	715	815	915	2315	2415
16	116	216	316	416	516	616	716	816	916	2316	2416
17	117	217	317	417	517	617	717	817	917	2317	2417
47	147	247	347	447	547	647	747	847	947	2347	2447
48	148	248	348	448	548	648	748	848	948	2348	2448